Reliability Analysis based Condition Monitoring of Process Equipments

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Abstract

In recent years several contributions have been provided concerning condition monitoring techniques, ranging from theoretical analysis of the topic to practical applications across several industrial sectors. The scope of condition monitoring techniques has been extended towards various industries. In this work the entire cane handling equipments of a sugar industry have been condition monitored and the health condition of cane handling equipments are obtained. And also, in this work, the Reliability assessment of cane handling equipments has been performed based on Failure mode effects and criticality analysis. By using these techniques, various recommendations have been suggested for better performance of cane handling equipments. The analysis performed in this work is very helpful in calculating Reliability and health condition of cane handling and thereby will improve the performance of the industry.

Keywords — *Condition monitoring, Reliability assessment, FMECA.*

I. INTRODUCTION (SIZE 10 & BOLD)

The main objective of a process industry is to condition monitor its equipment for maximum reliability and to determine its optimum processing condition to get the best output . It even focuses on to determine the best parameter which influences the process maximum.

Jinghuan Ma et. al.,(2012) described the major problem faced by the industry that how it can be assessed the product reliability in the manufacturing process as well as identify the manufacturing bottle neck which should be focused attentively by the reliability engineer in manufacturing process. To resolve this problem, a reliability assessment method of manufacturing process by using the Weibull analysis technology is presented.

Kostina M et.al (2012) developed a reliability assessment method with an extension of the existing ones and pooling them to a common framework. This system must identified the most unreliable parts of a production process and suggested the most efficient ways for the reliability improvement. This reliability assessment tool helps engineers quickly and with accurate estimates most unreliable places of production process and indicates ways of their elimination with greater efficiency.

Glenn Ballard (1999) explained that Improving work flow reliability is important for the productivity of linked production units, and consequently for project cost and duration.

Satyavati (2010) has explained that objective of every industrial manager is that industry should be in an operative state for a long period of time. Reliability Analysis can be benefit for the industry in terms of higher productivity and lower maintenance cost. This can also help the management to understand the effect of increasing/decreasing the repair rate of a particular component or sub system on the overall system.

Trevor et.al.(2001) stated a new Acoustic Emission based signal processing approach which can provide simple but sensitive means of detecting the presence and evolution of faults in very slowly rotating machinery. These developments have further led to the creation of what is believed to be the first easily retro fitted and affordable on line monitoring module for very slowly rotating machinery.

Alan Yarrow et.al., stated condition monitoring is to improve reliability and better target any maintenance effort. The purpose is to evaluate the use of condition monitoring in sugar mill maintenance procedures, explore the current state of the art, and look at future opportunities.

Rest of the work is organized as follows: FMECA is presented in section II. Section III deals with the FMECA for cane leveller. Section IV deals with Condition Monitoring of a process industry. The conclusions are presented in section V.

II. Failure mode effects and criticality analysis (FMECA)

In this work, primarily FMECA analysis on the cane handling equipment of sugar industry, has been performed as follows:

Failure Modes and Effects Analysis (FMEA) is a simple analysis method to reveal possible failures and to predict the failure effects on the system as a whole. If we describe or rank the criticality of the various failures in the FMEA, the analysis is often referred to as an FMECA(Failure Modes, Effects and Criticality Analysis).The Criticality is a function of failure effect and probability/frequency as seen below. To ensure a systematic study of a system a specific FMEA form is used. The FMEA form May for example includes the following columns:

Identification:

Here the specific component is identified by a description and/or number. It is also to refer to a system drawing or a functional diagram .The function of the component(i.e) its working task in the system is briefly described. The state of the component when the system is normal working condition is also described.

Failure Zones:

All the possible ways that the component can fail to perform its function are listed in this column. Only the failure modes that can be observed from "OUTSIDE" are listed down. The internal modes are considered as Failure Causes.

Effects On Other Units in the System: In those cases where the specific failure modes affects other components in the system, this is stated in this column. Emphasis should be given to identification of failure propagation, which does not follow the functional chains of functional diagrams.

Effect on the System:

In this column, we describe how the system is influenced by the specific failure mode. The operational state of the system as a result of failure should be noted down. For Example, whether the system is in operational state, or changed in other operational mode,or not in an operational state.

Corrective Measures:

Here we describe what has been done or what can be done to correct the failure, or possibly to reduce the consequences of failure. We may also list measures that are aimed at reducing the probability that the failure will occur.

Failure effect ranking:

The failure is ranked according to its effect with respect to reliability and safety, the possibilities of mitigating the failure, the length of repair time, production loss etc., we might for example use the following grouping of failure effects

Level C: A failure that doesn't reduce the functional ability of the system more than normally is accepted.

Level B: A failure that reduces the functional ability of the system beyond he acceptable level, but the consequences can be corrected and controlled.

Level A: A failure that reduces the functional ability of the system beyond the acceptable level and which creates an unacceptable condition, either operational or with respect to Safety.

Remarks: Here we state, for example assumptions and suppositions. By combining the failure frequency (probability) and failure effect (consequence),the criticality of specific failure effective mode is determined.

FMECA for cane chopper: Choppers are used to chop the raw sugar cane to small pieces to help it in proper crushing.

Table1. FMECA for cane chopper

Sl No:	Failure Zone	Level Of Probability Occurrence	Failure Cause	Failure Effect	Remedies
1	Knife ends	B	Over Loading	Improper Crushing	Proper Loading
2	Bearings	A	More vibration and Lack Of Lubrication	Stopping of Process	Proper Lubrication and Load management
3	Deflector plates	C	Increase In Temperature	Hazardous to worker	Welding the cracks and maintaining Proper Temperature
4	Motor Belt	C	Misalignment of Motor	Improper Crushing	Proper alignment of Motor
5	Downside plate	C	Temperature Plates	Failure of Downside Motor	Maintaining Cooling aids

After conducting FMECA for cane chopper we found that the main causes for failure are lack of lubrication, deflector plates and improper balancing.

III. **FMECA for cane leveller:**

Levellers are used to chop the already chopped small pieces to very small pieces to help it in effective crushing.

Table2. FMECA for cane Leveller

Sl No:	Failure Zone	Level Of Probability Occurrence	Failure Cause	Failure Effect	Remedies
1	Knife ends	B	Over Loading	Improper Crushing	Proper Loading
2	Bearings	A	More vibration and Lack Of Lubrication	Stopping of Process	Proper Lubrication and Load management
3	Side Plates	C	Increase In Temperature	Hazardous to worker	Welding the cracks and maintaining Proper Temperature
4	Motor Belt	C	Misalignment of Motor	Improper Crushing	Proper alignment of Motor

After conducting FMECA for cane Leveller we found that the main causes for failure are lack of lubrication, side plates and improper Knives spacing.

Table3. FMECA for cane Fibirizer

FMECA FOR CANE FIBIRIZER:

Sl No:	Failure Zone	Level Of Probability Occurrence	Failure Cause	Failure Effect	Remedies
1	Hammer ends	B	Over Loading	Improper Crushing	Proper Loading and changing the Hammer Tips
2	Bearings	A	More vibration and Lack Of Lubrication	Stopping of Process	Proper Lubrication and Load management
3	Oil Filter	C	Jamming of Filter and pump	Improper Lubrication of Bearings	Clearing Of Filter Continuously
4	Motor Belt	C	Misalignment of Motor	Improper Crushing	Proper alignment of Motor
5	Shaft	B	Variation in Process Parameters	Improper Crushing and Increase in vibrations	Maintaining the process parameters optimally

Fibirizers are used to hammer the very small pieces to sugar cane pulp to help it in effective juice extraction.

After conducting FMECA for cane Fibirizer we found that the main causes for failure are lack of lubrication, shaft misalignment and improper hammer ends.

Results from FMECA:

After conducting FMECA analysis, the following failure modes have been found as critical and needs important action:

1) In cane chopper failures are mainly at the Knife ends and bearings due to improper loading and variations in shaft running speed for which we need to maintain appropriate loading and reasonable shaft speed.

2) In cane leveller failures are at side plates due to change in temperature for which we need to maintain proper temperature and lubrication.

3) In cane fibirizer failures are mainly at bearing and hammer tips which occurs because of higher loading and improper lubrication for which we need to maintain good lubrication and operate at defined loading limits.

IV. Condition Monitoring

Condition monitoring is a process of monitoring a parameter of a condition in machinery ,in order identify a significant change which is indicative of developing a fault .It is a major component of predictive maintenance .The use of conditional monitoring allows the maintenance to be scheduled or other actions to be taken to prevent failure and avoid its consequences .Condition monitoring has a unique benefit in that conditions that would shorten the normal life span can be addressed before they develop into a major failure .Condition monitoring techniques are generally used on rotating equipments and other machinery.

Condition monitoring types:

The following list includes the main condition monitoring techniques applied in the industrial and transportation sectors

- Vibration condition monitoring
- Lubricant analysis
- Acoustic emission
- Infrared Thermography
- Ultrasound emission

Most condition monitoring techniques are being slowly standardized by ASTM and ISO.

Vibrational Condition Monitoring for Sugar Industry:

Vibrational analysis is carried on cane handling systems(cane leveler ,cane chopper, cane fibirizer).Here the displacement and velocity of vibration are taken. The velocity is compared to standard values (vibration standards ISO 10816)

Machine condition monitoring:

Shock pulse analyzer A2010 combines the functions of a shock pulse meter.A vibration meter and a tachometer it is used to check the operating conditions of a rotating machines in order to detect the mechanical faults and supply for effective preventive maintenance.

With A010,maintenance personnel can monitor all significant aspects of mechanical machine condition.The mechanical condition of rolling bearings,the lubrication condition of rolling bearings,general machine condition looseness,misalignment and out of balance on machine vibration.

The purpose of systematic condition monitoring:

To avoid unnecessary overhauls of the machine in good working conditions.to avoid replacements of routine seviceable bearings,to improve the life expectancy of rolling bearings by optimizing their lubrication.To detect trouble spots in time for planned repairs and replacements to avoid breakdowns and unnecessary production stops.

Instrument keys and functions:

The A2010 has three inputs,each with a different connector type,an specialized circuits for all three measuring functions .only live controls keys are needed to operate the instrument.

LCD display:

On four lines,the display shows menus,selected measuring mode,input data and measuring results.

Condition scale:

An arrow pointing at green,yellow,or red field of the condition scale provides an instant evaluation of the measured shock pulse or vibration level.

Green = good condition
Yellow = reduced condition
Red = bad conditon

Peak indicator:

In the ear phone mode,a blinking light shows the existence of shock pulse peaks above the displayed shock level.

Measuring key:

The M key starts the measurement.For continous vibration measurement,the key is held down.

Select key:

The set key initiates the setting of input data and earphone volume.

7/8 arrow keys:

The arrow keys are used to increase (7) or decrese (8) the values of input data and to change measuring thresholds in the earphone mode.

Input for shock pulse transducer:

A threaded conector receiving the coaxial cable from a hand held probe,a tranducer with quick connector or a measuring terminal

Input for earphone,tachometer:

Connecting the earphone or the tachometer probe will switch the A2010 to the respective measuring mode.

Input for vibration transducer:

A bayonet connector receiving the coaxial cable from the vibration transducer.

Meaurement of machine vibration:

Machine vibration is measured with a small piezo-electric accelelerometer.the transducer is normally attached with a magnetic base to a bearing housing or some other suitable measuring point.

The transducer can be pressed by hand against non- magnetic material it can be a long probe tip.

Tachometer functions:

A contact adapter can be placed over the lens .for rpm measurement ,it is fitted with rubber tipped contact center which is held firmly against the center of shaft.

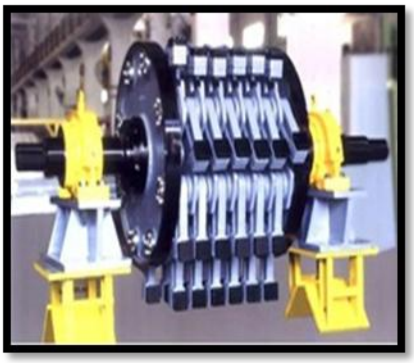
Vibration condition monitoring has been done on the following three equipments in a sugar cane:

- Cane chopper
- Cane leveller
- Cane fibrizer

Cane chopper:

Cane leveller:

Cane fibrizer



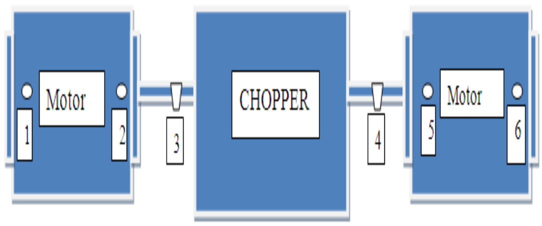
Vibration condition monitoring of sugar industry:

Vibration Condition monitoring in a sugar industry is done on three equipments Cane chopper,Cane leveller,Cane fiberizer.There is a mechanical probe for the vibrometer which is placed on the shaft at six various positions. For the Cane chopper,Cane leveller, Cane Fibirizer at 6 different positions vibrational velocity and displacement are taken. We have taken Velocity and displacement in 3 different directions.

- Axial
- Vertical
- Horizontal

Vibration condition monitoring of a cane chopper:

- Vibration condition monitoring of a cane chopper in the sugar industry is done by using vibrometer which is placed on the shaft at six various positions



The values of velocity and displacement are taken in 3 different directions

- Axial
- Vertical

Horizontal

Table4: The values of velocity and displacement of a cane chopper :

Direction of measurement	Vibrational amplitude and conditions							
	Position 1		Position 2		Position 3		Position 4	
	Disp	Vel	Disp	Vel	Disp	Vel	Disp	Vel
HOR	14	2.6	12	2.7	40	3.6	64	5.4
VER	47	3.7	20	2.2	35	3.8	32	3.2
AXL	20	3.1	22	2.9	45	5.2	61	5.6
CONDITION	Good				Good			

The above table depicts the values of displacements and velocities at different positions on a cane chopper.

The Values are depicted using a vibrometer and balancing of the shaft is done according to the vibrational velocities. The balancing is done using wedges and welding equipment which is a very heavier process.

The Analysis Reveals The Following:

Though the health condition of the equipment is in good category, minor axial play at both chopper bearing is indicated.

Recommendations:

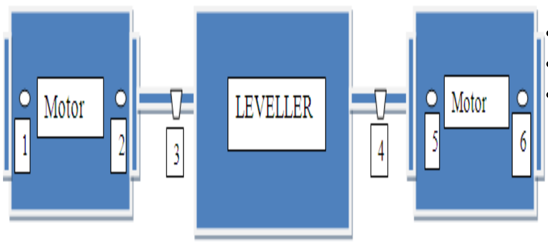
Inspect for looseness/axial play at both chopper and tighten the adaptor sleeve if provided.

Corrective actions are required in case the velocity exceeds 11.0 mm/s.

Monitor the trend at regular intervals.

Vibration condition monitoring of a cane leveller:

Vibration condition monitoring of a cane leveller in the sugar industry is done by using vibrometer which is placed on the shaft at six various positions.



The values of velocity and displacement are taken in 3 different directions

- Axial
- Vertical

Horizontal

Table5: Velocity and displacement of cane leveller

Direction of measurement	Vibrational amplitude and conditions							
	Position 1		Position 2		Position 3		Position 4	
	Disp	Vel	Disp	Vel	Disp	Vel	Disp	Vel
HOR	8	1.1	6	.9	31	2.0	20	1.3
VER	6	0.8	5	1.0	15	1.1	11	1.2
AXL	14	1.2	16	2.6	24	2.0	30	2.4
CONDITION	Good				Good			

The above table depicts the values of displacements and velocities at different positions on a cane leveller.

The Values are depicted using a vibrometer and balancing of the shaft is done according to the vibrational velocities. The balancing is done using wedges and welding equipment which is a very heavier process.

The Analysis Reveals The Following:

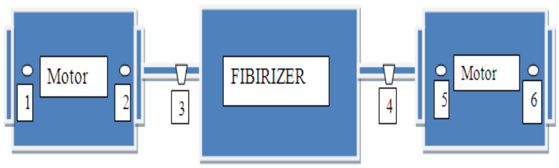
Though the health condition of the equipment is in good category, minor axial play at both chopper bearing is indicated.

Recommendations:

Inspect for looseness/axial play at both leveller and tighten the adaptor sleeve if provided. Corrective actions are required in case the velocity exceeds 11.0 mm/s. Monitor the trend at regular intervals.

Vibration condition monitoring of a cane fibirizer:

Vibration condition monitoring of a cane fibirizer in the sugar industry is done by using vibrometer which is placed on the shaft at six various positions



The values of velocity and displacement are taken in 3 different directions

- Axial
- Vertical
- Horizontal

Table6: Velocity and displacement of cane fibirizer

Direction of measurement	Vibrational amplitude and conditions											
	Position 1		Position 2		Position 3		Position 4		Position 5		Position 6	
	Disp	Vel	Disp	Vel	Disp	Vel	Disp	Vel	Disp	Vel	Disp	Vel
HOR	31	3.7	30	6.1	250	30.3	160	17.6	16	1.6	22	1.7
VER	19	2.5	15	3.0	108	17.3	52	9.1	29	2.6	38	2.9
AXL	26	2.4	24	2.9	41	9.3	69	6	24	2.1	30	2.3
Condition	Good				V. Rough				Good			

The above table depicts the values of displacements and velocities at different positions on a cane leveller. The Values are depicted using a vibrometer and balancing of the shaft is done according to the vibrational velocities. The balancing is done using wedges and welding equipment which is a very heavier process.

The Analysis Reveals The Following:

Though the health condition of the equipment is in good category, rough axial play at both fibirizer bearing is indicated.

Recommendations:

Critically review the fit between hub and the shaft as looseness is indicated.

It is recommended to procure spare fibirizer rotor assembly along bearings and housings as a set. Ensure the fits and tolerances are maintained as per good engineering practices.

Till the above recommendations are implemented, close observation of this equipment from the point of abnormal knocking noise and increase in vibration levels is recommended.

Presently the highest value indicated is 12.2 mm/sec in "On load" condition. In case vibration levels exceed 21.0 mm/sec and knocking noise increases carry out inspection and rectifications.

V. Conclusions:

Reliability analysis and condition monitoring are the important performance measuring tools for process equipments. In this work the entire cane handling equipments of a sugar industry have been condition monitored and the health condition of cane handling equipments has obtained. In this work, the Reliability assessment of cane handling equipments has been performed based on Failure mode effects and criticality analysis. By using these techniques, various recommendations have been suggested for better performance of cane handling equipments. The analysis performed in this work is very helpful in calculating Reliability and health condition of cane handling and thereby will improve the performance of the industry. This type of analysis is very useful and economical for plant managers, supervisors in process industries.

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Bibliography:

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